Docket No.: 1592-0164PUS1
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Eiichi SHIMIZU et al.

Application No.: 10/589,348 | Confirmation No.: 8171

Filed: August 11, 2006 | Art Unit: 1792

For: VAPOR PHASE GROWTH APPARATUS | Examiner: R. N. Kackar

DECLARATION UNDER 37 CFR 1.132

MS Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Madam:

I, Eiichi SHIMIZU, declare and say as follows:

I am familiar with U.S. Application Serial No. 10/589,348, of which I am a co-inventor. I have reviewed all Office Actions issued in connection with this application. I have also reviewed all of the references cited by the Examiner in these Office Actions.

The following shows that the present invention achieves superior and unexpected results over the prior art.

In the present invention, a recess portion depressed in a dome shape is formed at the back surface of the wafer containing member (i.e., a dome shaped space is provided between the wafer containing member and the heat uniformizing member).

Gurary disclose various structures of the wafer carrier (FIGS. 4A to 12A) including structures where a space is provided between the wafer and the wafer carrier (i.e., a space is formed on the front surface of the wafer carrier). When a space is provided between the wafer and the wafer containing member as in Gurary, delivering and receiving of heat becomes complicated within the space. This is because there is heat emission from the wafer and from the wafer containing member and there is heat conduction in the wafer, the wafer containing member and the space therebetween. Further, the temperature distribution is deteriorated because convection in the space becomes large due to the heat produced by heat emission and heat conduction.

It is difficult to make adjustments so as to improve the temperature distribution by varying the shape of the space in the case where the space is provided between the wafer and the wafer containing member. I have attempted to improve the temperature distribution within the surface of the wafer by making the contacting area of the wafer and the wafer containing member be a simple plan surface and by using a space at the back surface of the wafer containing member, that is, by using a space provided between the wafer containing member and the heat uniformizing member. The present invention was achieved based on experimentations, and verification was conducted based on thermo-fluid analysis. The preferred shape of the space (i.e., a dome shape) was discovered based on experimentations, and its effect calculated based on thermo-fluid analysis. All experiments were conducted under my supervision or control.

In the conventional vapor phase growth apparatus shown in FIG. 5 of the present application, the central portion of the surface of the wafer containing member including the wafers has a higher temperature than the edge portion thereof due to the heating method employed and the installed position of the heating member, or due to differences in thermal conductivity among the heat uniformizing member (susceptor), the wafer containing member and the wafers, and contact thermal resistance thereof. In a conventional vapor phase growth apparatus, a spindle is disposed so as to be sandwiched by the heating members on both sides. Therefore, among the heat which is transmitted to the heat uniformizing member, there is heat which is transmitted directly to the heat uniformizing member in the upper direction from the heating members, and heat which is transmitted indirectly to the central portion of the heat uniformizing member via the spindle, which is transmitted from the side directions of the heating members. The central portion of the heat uniformizing member and the central portion of the wafer containing member, which are positioned above the spindle, are greatly affected by the heat which is transmitted via the spindle, in addition to the heat which is directly transmitted from the heating members, causing the temperature thereof to rise. The quantity of heat transmitted to the heat uniformizing member from the spindle is gradually reduced upon approaching the edge portion of the heat uniformizing member. When a wafer containing member contacts with and is placed on the heat uniformizing member without having a space therebetween and when the heat is transmitted to the wafer containing member from the heat uniformizing member, the heat quantity is also gradually reduced upon approaching the edge portion of the wafer containing member. Therefore, the temperature at the central portion of the

wafer containing member becomes higher than the temperature at the edge portion in the surface of the wafer containing member.

In the present invention, the spindle is also disposed so as to be sandwiched by the heating members on both sides. Heat is transmitted directly to the heat uniformizing member from the heating members, and heat is transmitted indirectly to the central portion of the heat uniformizing member via the rotary shaft. Thus, in the heat uniformizing member, the heat quantity is gradually reduced upon approach to the edge portion from the central portion. In order to uniformize the temperature at the central portion and the temperature at the edge portion of the surface of the wafer containing member (when the heat reaches the surface of the wafer containing member from a heat uniformizing member in which the distribution of heat quantity is not uniform), it is necessary to control the heat quantity which is transmitted from the heat uniformizing member so that it gradually increases upon approach to the edge portion from the central portion of the wafer containing member, thus compensating for the temperature difference between the central portion and the edge portion.

I discovered that forming a recess portion in a dome shape at the back surface of the wafer containing member, in order to provide a space between the wafer containing member and the heat uniformizing member, produces unexpectedly superior results. Superior and unexpected results, such as a temperature difference between the central portion and the edge portion at the surface of the wafer containing member of 5°C or less, and a temperature distribution within the surface of the wafer of 1°C or less, were obtained by forming a space at the back surface of the wafer containing member in a recess portion in a dome shape and by adjusting the height of the dome shape as described in the specification.

The attached data, based on thermo-fluid analysis (computer simulation), shows that the temperature distribution within the surface of the wafer is about 9°C in the comparison example, whereas the temperature distribution within the surface of the wafer is about 2°C in an embodiment of the present invention. As such, uniformity of the temperature between the central portion and the edge portion of the wafer containing member and uniformity of the temperature distribution within the surface of the wafer are achieved in the present invention, as compared to Gurary.

Further, the optimum value for the ratio of the height and the diameter H/D of the dome shape has also been obtained based on experimentations and verifications by thermo-fluid analysis (computer simulation).

<Present Invention>

By optimizing the dome shape at the side of the wafer containing member, which is opposite from the side in which the wafer contacts, a temperature distribution within the wafer surface placed on the wafer containing member equal to or lower than 2°C can be achieved (609 to 611°C).

<Comparison Example>

The temperature distribution when the side of the wafer containing member which is opposite from the side in which the wafer contacts is made to be a simple plan surface is shown. The temperature distribution within the wafer surface is about 10°C (622 to 632°C).

Although the present invention was achieved based on experimental trials, the above data is based on a computer simulation. Temperature distribution measurements are based on computer simulations, since actual measuring of the temperature distribution on the wafer surface cannot be carried out within a vapor-phase growth process. Attached is detailed information on the computer simulations.

As shown by the data enclosed herewith, in the present invention, the contacting area of the wafer and the wafer containing member is made to be a simple plan surface, and by improving the temperature distribution within the wafer surface by using the space at the back surface of the wafer containing member, superior and unexpected effects, which could not have been anticipated or suggested by a person skilled in the art, were obtained.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

____
Signature

Eiichi Shimizu
Typed or Printed Name

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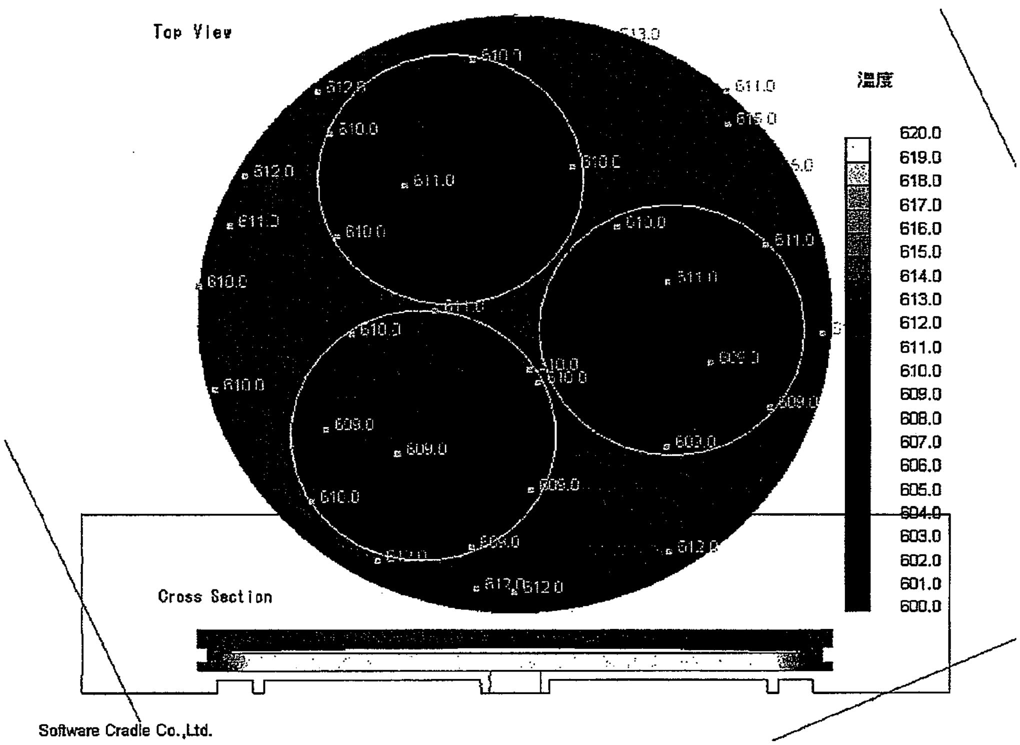
Date


Top View
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618.0
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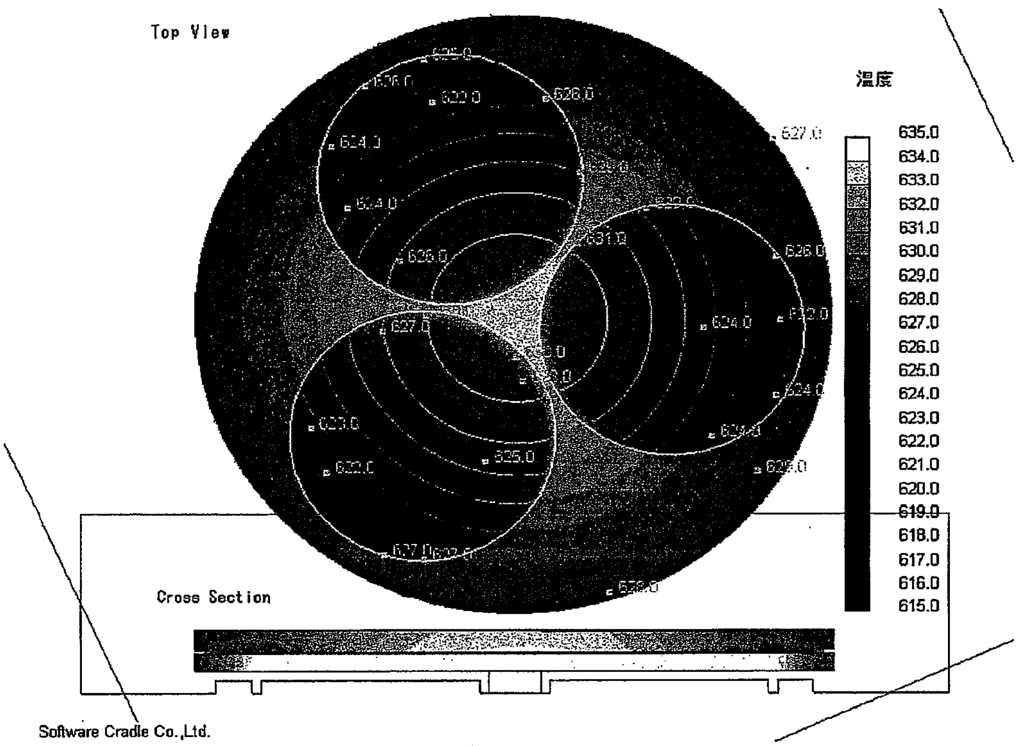
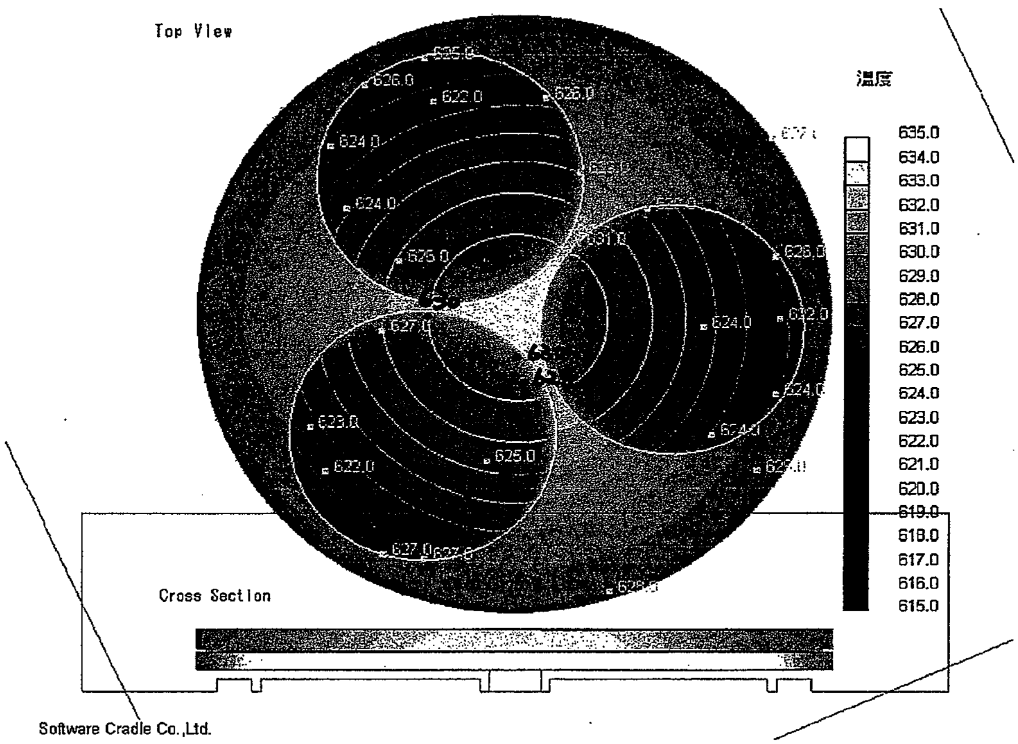
Cross Section
Software Cradle Co.,Ltd.

Embodiment:



Comparison example:



Comparison example:

<detail information of simulation>

software:

http://www.cradle.co.jp/en/product/tetra.htm

SC/Tetra is an all-in-one package Computational Fluid Dynamic (CFD) software using un-structured mesh (tetrahedron, pentahedron and hexahedron) and was developed with the concept as "Enabling the calculation of a complex geometry easiliy" in 1998.

SC/Tetra is a usability-focused software, and its concept is to enable the calculation of a complex geometry easily . It provides the automatic mesh generation that was considered to be difficult and Wizard based condition settings that guids an user to set up each conditions step by step.
Not to mention a flow and heat problems, SC/Tetra can calculate various phenomena such as Chemical Reactions and Arbitrary Lagrangian Eulerian for moving and/or rotating boundaries (ALE), Noise Analysis.

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computational model
http://www.cradle.co.jp/en/product/tetrav7/tetra_solver.htm
Numerical scheme->Discretization method->Finite volume method

SCRYU TETRA : VERSION 3
(finite volume method)

LCE0505_comparative example
element count: 5589753
steady analysis
cycle number for steady determination over 2000
boundary condition:
viscous boundary wall surface/No Slip
thermo-fluid boundary temperature setting boundary adiabatic boundary inflow-outflow

LCE0517_working example
element count: 6198321
steady analysis
cycle number for steady determination over 2000
boundary condition:
viscous boundary wall surface /No Slip
thermo-fluid boundary temperature setting boundary adiabatic boundary inflow-outflow

DECLARATION

I, Haruko OSAWA of c/o KOYO INTERNATIONAL TECHNICAL INSTITUTE, INC., 5F Nikko Kagurazaka Building, 18 Iwato-cho, Shinjuku-ku, Tokyo, Japan, do hereby solemnly declare that the attached English translation is an accurate translation of a portion of Japanese Patent Application No. 06-124901 to the best of my knowledge.

Declared at Tokyo, Japan

This 4th day of August, 2009

Haruko Osawa

Haruko OSAWA

Yoshiyuki Kamata (JP06-124901)

(Column 7, lines 10 to 22)

Fourth embodiment

FIG. 10 is a partial cross-sectional diagram showing another example of the quartz spacer used in the method of the present invention.

[0033] The upper surface 10c of the quartz spacer 10 is a smooth surface and a semiconductor substrate is mounted on the upper surface 10c. Further, the lower surface 10b is a spherical surface in which the area ration radius is 300mm, for example. When the quartz spacer 10 is mounted on the susceptor 11, a dome-shaped space is formed between the susceptor 11 and the quartz spacer 10. For example, when the semiconductor substrate is mounted on the quartz spacer 10 and when the susceptor 11 is heated by being induced in the above described state, the surface temperature of the substrate shows a distribution which corresponds to the shape of the dome-shaped space. Therefore, the composition of the compound semiconductor thin film which grows on the substrate also varies so as to correspond to the temperature.